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NOAA/NOS BATHYMETRIC DIGITIZATION PROGRAM RUNBATHY

By

L.E. Eber

ADMINISTRATIVE REPORT LJ-92-26

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NOAA/NOS BATHYMETRIC DIGITIZATION PROGRAM
RUNBATHY

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INTRODUCTION

RUNBATHY is a group of programs that allow the user to make detailed bathymetric maps and calculate areas of the sea floor for specified locations and depth ranges. Maps or area calculations may involve depth intervals as small as 10 meters or 10 fathoms.

The RUNBATHY programs were written in Quick Basic version 4.5 and Turbo Pascal version 6.0. They run under MS-DOS version 5.0 and MS Windows version 3.1. A program information (PIF) file for Windows is included with the program package.

The NOAA/NOS bathymetry obtained from multibeam mapping of the sea floor in the Exclusive Economic Zone is provided in units representing areas one degree of longitude by one-half degree of latitude (with some exceptions). Depths are recorded in meters and two types of gridded data are available. One type is the Universal Transverse Mercator grid for which the resolution of the data is 250 meters (i.e. depths are given for grid points 250 meters apart). The other type is a geographical grid for which the resolution is 15 seconds of latitude and longitude (i.e. depths are given for grid points about 463 meters apart). RUNBATHY was written to process data in the geographical grid format.

Each unit of data, or map, comes with two data files (one for each grid), two information files (one for each grid), and a README file which describes the EEZ mapping program. Data in the geographical grid are in the file with the name extension <GRD>. The information file for the geographical grid has the name extension <PRG>. These two files (approximately 225 kb) must be copied into a disk directory with enough space (up to 20 mb) to hold intermediate and final output files. This will be the designated data directory for output files. Before starting RUNBATHY, the filename extension of the NOS data file (in the data directory) should be changed from <GRD> to <NOS>. Then the NOS file must be viewed with a text editor. If the first line in the file is <DSAA>, it must be deleted along with the next four lines. The deleted lines are identification fields. After editing, the first line in the file should be a depth value. The *.PRG file should not be altered. When these two files are in place, the map unit is ready for processing. The original files from NOS should be backed up and stored in a safe place.

RUNBATHY and all of its affiliated program and parameter files must reside in the DOS default directory. The default directory can be the designated data directory, if you choose, but RUNBATHY creates a large number of data files and it may be preferable to keep the program files separate. Some data files serve primarily to pass data from one program to another and are deleted automatically when no longer needed. Others can be deleted at the user's discretion when processing for a unit is completed. The naming of output files is performed automatically where possible. Output filenames are derived from the names of the NOS data files. They consist of six letters (a contraction of the map name) followed by G1. The user must enter the correct filename for the unit to be processed and specify meters or fathoms for depth units. The program replaces the <1>, in the NOS filename, with <M> for meters or <F> for fathoms, to make the base name for output files. For example, the NOS filename for the Monterey Canyon map is MONTRYG1.NOS. The names of output files for this map will be either MONTRYGM.* or MONTRYGF.*, depending on the user's selection of meters or fathoms. Extensions for naming output are chosen by the program to help identify the contents of each

file. They are described in more detail in subsequent sections.

Figure 1.

PROGRAM SELECTION MENU

- _ EEZ_GRID..create parameter file for EDMAP.
- _ EDMAP.....digitize bottom contours in specified units.
- _ SET_MXMN..identify maxima and minima for contour segments.
- _ SORT_BOT..sort contour segments by increasing depth.
- _ MERG_BOT..combine files of contour segments.
- _ FINDAREA..compute areas between specified contour pairs.
- _ PRNTHDRS..view or print contour segment header records.
- _ ZOOMPLOT..diagnostic utility to display contours on the screen.
- _ WPDRIVER..create an HP-GL file for WordPerfect 5.1 graphics.
- _ DOSCOMMAND..execute a DOS command and return to this menu.

Move cursor to select program. Press <ESC> to exit.

The main menu (Figure 1) provides access to all of RUNBATHY's functions. The first four menu items provide the means to process the data for a map unit and create files of digitized bottom contours. MERG_BOT and FINDAREA can be used to combine the files and to compute areas between contours. Other items list options for graphic display of the digitized output. The sequence of processing is described briefly by the following steps.

Copy data files from the distribution disk and rename the *.GRD file to *.NOS. Edit the *.NOS file to remove five identification records (starting with the characters <DSAA>), if present. Use EEZ_GRID to verify the count of depth values in the *.NOS file and to create a parameter file (*.PRM) for subsequent use by EDMAP.

Use EDMAP run No. 0 to reformat the *.NOS data file and create a new file (*.GRD) in the format required by EDMAP for subsequent runs.

Use EDMAP to scan the *.GRD file and digitize contours at intervals of ten meters or ten fathoms. Save the digitized contours in binary files with extensions CT1, CT2, etc. (10 files for meters, 5 files for fathoms).

Use SET_MXMN to identify and label each digitized contour segment with a segment type and an attribute of maximum or minimum (as explained in a later section). Save results in ASCII files with extensions BT1, BT2, etc.

Use SORT_BOT to sort digitized contour segments in order of increasing depth. Save results in ASCII files with extensions BO1, BO2, etc.

Use MERG_BOT to merge all of the files of digitized contours (of like units) for one map unit into one file with extension ALL.

Use FINDAREA to compute areas between contours at intervals of ten meters and ten fathoms for the entire map. Examine and verify the resulting output files.

Make merged files of digitized contours (*.ALL) and program FINDAREA available to investigators who need to compute areas for specified locations and depth ranges.

These steps must be performed separately for meters and fathoms. They do not make reference to the utility programs PRNTHDRS, ZOOMPLOT or WPDRIIVER, which are useful for diagnostic or purposes but are not essential to the basic processing sequence.

followed by <G1> (for example, MONTRYG1). The initial run of EDMAP (run No. 0) reads and reformats the NOS data file and creates a new data file with extension <GRD>. Subsequent runs of EDMAP load the *.GRD file into memory and use it to digitize contours. This step, and those that follow, must be performed separately for calculations in meters and fathoms.

During run No. 0, data from the source file (*.NOS) are loaded after the message <ENTERED FETCHDAT> appears on the screen. When this process is completed (for a standard map unit) you should see:

```
29161 Records read from source file.  
29161 Values selected for data file.
```

```
ENTERED ANALFLD
```

```
29161 Values accepted from data file.  
0 Values rejected.
```

The number of records read (first line) is the count of depth values read from the NOS data file. It should agree with the number of grid points computed from the numbers of rows and columns. Otherwise, the integrity of the data file is in doubt. The number of values selected (second line) should equal the number of records read except when the map is incomplete, as is the case when it includes any land or shallow water areas that were not scanned. Depth values for gridpoints in unscanned areas are recorded as zeros and are not processed by EDMAP. The number of values accepted (shown on the line below ENTERED ANALFLD) should always equal the number of values selected. The numbers of selected and accepted values will differ only when a quality control option for source data is enabled (in RUNBATHY it isn't) and some of the selected values are rejected.

In addition to the *.GRD file, run No. 0 produces a file (*.MXN) that contains the coordinates and depth values of all local maxima and minima on the map. These files are used by SET_MXMN to help identify contour segments. The *.GRD files are also required by ZOOMPLOT for displaying the bottom contours on the screen in color. You can skip run No. 0 if the *.GRD and *.MXN files were generated in a previous session.

When continuing with EDMAP after run N0. 0 is completed, you will be asked what run number to start with. EDMAP digitizes contours at intervals of either 100 meters or 50 fathoms. The run number, and the shallowest depth, determine the offset (from 0) for the initial contour selection. For example, if the run number = 1 and the shallowest depth = 125 and units = meters, the selected contours would be 210, 310, 410, etc. If the run number = 1 and shallowest depth = 125 and units = fathoms, the selected contours would be 160, 210, 260, etc. Therefore it takes 10 runs to get all of the contours for intervals of ten meters and 5 runs for intervals of ten fathoms.

You will have the option to stop the program after each completed run or let it continue

automatically. If you choose the latter, program control will switch from EDMAP to SET_MXMN to SORT_BOT and back to EDMAP until all 5 or 10 runs (depending on the depth units) are finished. If you are running on automatic and want to return to manual control, do the following. Wait until the current program finishes and the green message box appears. The message box will stay on the screen for 5 seconds. If you press the <ESC> key during this time, the program will return to the main menu. It is not necessary to complete all 5, or 10 runs for a map unit in the same session. You can terminate a session after any run and continue where you left off in a later session.

8. Each run of EDMAP (except run No. 0) produces a file of digitized contour segments. After each run, you can return to the main menu or continue processing with SET_MXMN followed by SORT_BOT. SET_MXMN reformats the binary file created by EDMAP to an ASCII file and identifies each contour segment with a type and an attribute of either maximum or minimum. The contour segments are represented in these files by consecutive pairs of point coordinates. SET_MXMN modifies each segment by adding extra pairs of coordinates as necessary to make it completely enclose an area. The program then attempts to identify that area as a maximum or minimum and adds the designation (max or min) to the segment's header record. SORT_BOT creates a file of contour segments ordered by increasing depth, from the output of SET_MXMN.

9. Use MERG_BOT to combine all of the sorted files of digitized contours for a map unit with the same depth units. The sorted files are identified by the extensions BO1, BO2, etc. Up to ten files can be combined in one run. The combined file will have the extension ALL. The order of contour segments in the merged file will be by increasing depth. This order is necessary for computing areas with FINDAREA.

10. FINDAREA computes areas for sorted, merged contour segments in files created by MERG_BOT, named *.ALL. These files each contain all of the digitized contour data at intervals of 10 fathoms or 10 meters, for one map unit. FINDAREA should be run routinely as the last step in processing a map unit, using the full range of depths on the map and the minimum depth interval (10). This will serve to verify the integrity of the digitized contour files. FINDAREA creates two output files. One contains the computed areas between each pair of contours and will be referred to here as the *.KMS file (in practice, it will be named by the user). The other contains the identification, including type and max/min designation, and area for each segment. It will have the name *.LOG.

The first thing FINDAREA does, after opening a *.ALL file, is compute the area of the corresponding map unit (or that portion of it defined by the specified latitude and longitude boundaries) and display it in the lower right corner of the screen. During execution it accumulates a checksum of areas between the successive pairs of contours and, when through, displays the checksum below the map area. If they are not the same, an error is indicated. The error may be in the *.all file or it may have been made by FINDAREA. If the map area and the checksum are the same, the areas between contours still cannot be accepted as correct with certainty. Additional verification is required, and can be carried out by inspecting the contents of the *.KMS file. The areas are listed for successive pairs of contours beginning with the shallowest. An area which

differs by a factor of ten or more from adjacent areas may be in error and should be checked out. To do this, find the contour segments bordering the area in question in the *.LOG file. The area between two contours is obtained by combining the individual segment areas listed in the *.LOG file, as follows. Areas associated with the shallower of two contours are added if designated as maxima, or subtracted if designated as minima. Areas associated with the deeper of two contours are subtracted if designated as maxima, or added if designated as minima. If any segment area is incorrectly designated, the combined area will be incorrect. Use ZOOMPLOT to verify maximum/minimum designations for questionable contour segments as follows. Run ZOOMPLOT and enter the name of the *.BO* file that contains the target contour. Enter the depth of the target contour for both shallowest and deepest depths. Enter 100 for the depth interval. Enter latitude and longitude boundaries for the map unit. Select the paint option and enter 1 for the scan code. The display will contain all segments of the questionable contour. Segments colored magenta are minima, those colored red are maxima. Compare the designation of each segment in the *.LOG file with the color shown on the screen. For each discrepancy, locate the segment header record in the *.BO* file and correct the maximum/minimum designation. If an error is found in a *.BO* for meters it will probably also exist in the corresponding file for fathoms, and vice versa. Rerun MERG_BOT with the corrected *.BO* files. Rerun FINDAREA with the corrected *.ALL files. Repeat the verification procedures. If the displayed contour segments are confined to a small portion of the map, the boundaries submitted to ZOOMPLOT can be adjusted in order to expand that portion to full screen size.

Another kind of error is related to sectors of undefined depths on incomplete maps. This problem can be diagnosed with reference to the *.LOG file and to the graphic plot of the contours. It is discussed in the section: Incomplete maps.

FINDAREA will be distributed with the digitized contour files, *.ALL, so that requestors of the data can compute their own areas. It is expected that the boundaries of target locations specified by users will not generally coincide with the boundaries of the map units associated with the *.ALL files. FINDAREA will attempt to compute areas in any portion of a map unit defined by pairs of latitudes and longitudes. Partitioning a map can divide a segment into two or more pieces and/or change its type. If FINDAREA fails to cope with the side effects of partitioning map units, errors in the computed areas will occur. In that case, re-defining the partition with different latitude or longitude boundaries may resolve the problem. If not, call the hotline and hope someone answers.

When running FINDAREA, the user is prompted to enter the latitudes and longitudes that enclose the target location. He/she must also enter maximum and minimum depth values, and a depth interval. These values must all be multiples of 10. The units (meters or fathoms) must be specified. Finally, the user must enter the drive and path specification for the directory containing the *.ALL files of digitized contours, and a name for the output file. FINDAREA will scan the designated directory and take note of all files with the <ALL> extension. It will open each of these files, in turn, and compute areas for the specified depth range and intervals for that portion of each map (if any) contained within the target location. The results are accumulated in memory until all of the files in the list have been processed and then saved in the designated output file.

A second output file (with extension <LOG>) will be saved on disk with the identifications, types, attributes and areas of the individual segments. This file is of use primarily in the verification process, before the digitized contour files are distributed.

When FINDAREA is running, it displays a screen graphic outlining those map units that are all, or in part, within the target location. As each unit is processed, the box on the screen representing that unit is filled with hatching. When the program is finished, the user can see clearly what parts of the target location (if any) were not represented by the *.ALL files.

DIAGNOSTIC UTILITIES

Print headers utility

The merged files of digitized contours (*.ALL) vary in size from less than one megabyte to more than three megabytes. Many text editors do not handle files of a megabyte, or larger size, very well and some will not handle them at all. Program PRNTHDRS provides an option to scan the contents of a digitized contour file by displaying the header records on the screen. The header records can also be printed or copied to a file. Each contour segment has a header record. Header records identify a segment by its depth and units (meters or fathoms), its length (number of coordinates), its type (corner, vertical, closed, etc.) and its designation of maximum or minimum. A segment that was not successfully identified as a maximum or a minimum will be labeled as <mxmn>. With early detection, the segment can be diagnosed and corrected before running FINDAREA. Otherwise, the segment will be passed over by FINDAREA in computations of areas between contours.

Screen and print display utilities

Contour patterns can be displayed on the graphics screen with ZOOMPLOT. ZOOMPLOT works with the *.BO1, *.BO2, etc. files created by SORT_BOT and the *.ALL files created by MERG_BOT. ZOOMPLOT provides options to expand any portion of a map to full screen size and to display only those contours that the user specifies. It can be used to help verify the identification of local maxima and minima.

When ZOOMPLOT displays bottom contours on the screen it also creates a file of plot calls (*.PLT) which correspond to each feature drawn on the screen. The program WPDRIVER can be used to convert the contents of an *.PLT file to HP-GL graphics code and save it in a new file. The latter can be loaded by WordPerfect 5.1 and printed in graphics mode. To accomplish this, run WPDRIVER and select the sideways option for maximum plot size. Then from WordPerfect 5.1, use ALT_F9 to bring up the graphics menu. Select 1 (figure), <ENTER>. Select 1 (create), <ENTER>. Select 1 (filename), type the filename, <ENTER>. If successful, WordPerfect will load the file. To maximize the plot size, select 7 (size), <ENTER>, Select 1 (set width), <ENTER>. Select 9 (inches), <ENTER>. Exit the graphics menu with F7. Use Shift_F7 to bring up the print menu and select 1 (full document) to print the file.

Incomplete maps

Map units that include unscanned areas in shallow water or land areas are incomplete. Depths are recorded as zeros in the NOS data files for gridpoints in unscanned areas. Contour fragments, with dangling end points, which do not connect with a border or each other, can result from digitizing in the vicinity of unscanned areas. Such fragments have no definable interior and hence, no computable area. They are rejected by SET_MXMN and do not cause a problem. Closed segments near the unscanned areas, however, can lead to incorrect computation of areas. On an incomplete map, the shallowest contour that isolates the unscanned area from the rest of the map defines a boundary for valid area computations on that map. For example, on the incomplete Farallon Islands map, the shallowest contour that isolated the unscanned area was 230 meters. However, two shallower contours were present in the contour

segment file, one was 220 meters, the other 210 meters. Both were small open segments on the right border. The area between 210 and 220 meters was correctly computed because the 220 contour completely enclosed the 210 contour. The area computed between 220 and 230 meters was invalid because it included all of the unexamined area. When this kind of error occurs, the file of contour segments (*.ALL) must be edited and the segments contributing to invalid computations should be deleted before the file is distributed.

METHODOLOGY OF COMBINING AREAS

Organizing the bathymetric data into map units with dimensions of one half degree latitude by one degree longitude was beneficial in that it resulted in data files of convenient size for distribution, and grid dimensions small enough for the memory capacity of desktop computers. It did, however, pose a need for a strategy to process the data separately for each unit such that the results could be combined in an objective manner.

This strategy is based on the premises that every contour segment in a unit encloses a definable area and that segment areas can be combined with other segment areas in the same unit or other units to compute areas between contours. Counter segments digitized by EDMAP begin and end on map unit boundaries for the most part, and do not enclose areas. To implement the adopted strategy, each such contour segment was extended around the perimeter of the map, in a clockwise sense, until it became a closed segment. Through this process every segment has an interior area which can be identified as a maximum or minimum with respect to the area outside the segment. The rules used to extend segments and define their interiors are described below.

If a contour segment begins and ends on the same border, the interior area is that between the segment and the portion of the border that connects its end points. If a contour segment isolates a single corner, its interior is the area between the segment and that corner. If a contour segment connects the top and bottom borders, its interior is the area between the segment and the right border. If a contour segment connects the left and right borders, its interior is the area between the segment and the top border.

The method of defining a segment's interior, together with its location on a map unit, are used to assign it a segment type. Each type is identified by a number. Knowing what the type numbers mean can be useful in locating segments on a map. The types are defined in the table below. The expression 'closed' in this table refers to segments that are entirely interior to a map; 'open' refers to segments that touch only one border. Other types are either self explanatory or are defined under Description.

Type	Description
0	horizontal segment, right border to left border.
1	open segment on lower border.
2	open segment on upper border.
3	corner segment, lower right.
4	corner segment, upper right.
5	corner segment, lower left.
6	corner segment, upper left.
7	vertical segment, lower border to upper border.
8	open segment on left border.
9	open segment on right border.
11	closed segment, no contact with any border.

COMBINING MAP UNITS

Program EXTENDIT can be used to combine adjoining map units that have the same range of latitude. It is included with the RUNBATHY software but is not on the RUNBATHY menu. It was used to combine the Pioneer Canyon map and the Palo Alto maps which join at 123W longitude between latitudes 37N and 37.5N. The Palo Alto map consists mostly of undefined depths. Only the portion between 122.5W and 122.0W was used in the combined map. The file name of the new map unit is PIOPALG1.NOS. The range of longitude on the new map is 1.5 degrees (122.5W - 123.0W), which is the maximum allowable range. This constraint prevents program EDMAP from trying to allocate too much memory when processing the data. When EXTENDIT is used to make a new map unit, a new parameter file, *.PRM, must also be created, with adjusted values for minimum and maximum longitudes, the number of columns and the shallowest and deepest depths.

When EXTENDIT is executed, it will ask for the names of the two files to be combined, a name for the new file, the numbers of rows and columns in each of the old files and the number of columns to copy from the inshore file to the new file. All of the offshore file will be copied to the new file. Your entry for the number of columns to copy from the inshore file will determine how much of the western portion of that file will be copied. For example, the new file PIOPALG1.NOS was created from PIONERG1.NOS and that portion of PALALTG1.NOS from 123.0W to 122.5W. To determine the number of columns to be copied from this map, multiply the range of longitude by 240 and add 1, as follows: $(123.0 - 122.5) * 240 + 1 = 121$ columns. The correct number to enter for columns to copy is 121, however, the first column of each row will be skipped in the process because it is a duplicate of the last column of each row in the offshore map.

